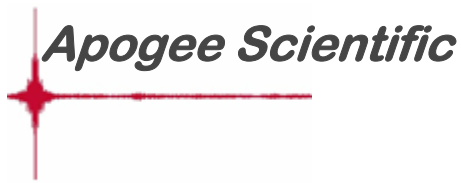
Mercury Control for Plants Firing Texas Lignite and Equipped with ESP + Wet FGD

NETL DE-FC26-06NT42779



DE-FC26-06NT42779
Project Overview

Full-scale Evaluation of Activated Carbon Injection and Toxecon™ II for Mercury Control at NRG Texas's Limestone Electric Generating Station

URS

Limestone Sorbent Injection Test Program
Technical Approach

- **Parametric tests to evaluate ACI performance**
  - **Effect of sorbent injection rate**
  - **Effect of sorbent type**
  - **Effect of fuel blend**
  - **Evaluate 3 ACI configurations**
    - **ACI upstream of ESP**
    - **Toxecon™ II**
    - **Combination/staged sorbent injection**

Limestone Sorbent Test Program
Technical Approach

- **Longer-term continuous injection test**
  - **60-day test**
  - **Test conditions determined from parametric results**
    - **Sorbent**
    - **ACI configuration and injection rate**
  - **Evaluate performance under normal plant operation**
    - **Load swings**
    - **Fuel variability**
    - **Balance of plant impacts**
      - **ESP operation**
      - **Byproduct characteristics**

URS

Limestone Sorbent Test Program
Expected Benefits

- **Full-scale ACI data for TxL-ESP removal**
- **Determine an approach for achieving required mercury emissions reductions in TxL-fired plant while maintaining suitable fly ash properties for resale applications**
- **Overall costs and feasibility of using ACI for mercury control in TxL-fired plants**

Limestone Sorbent Test Program Presentation Outline

- **Background**
- **Project Organization**
- **Technical Approach**
- **Schedule**
- **Milestones/Deliverables**

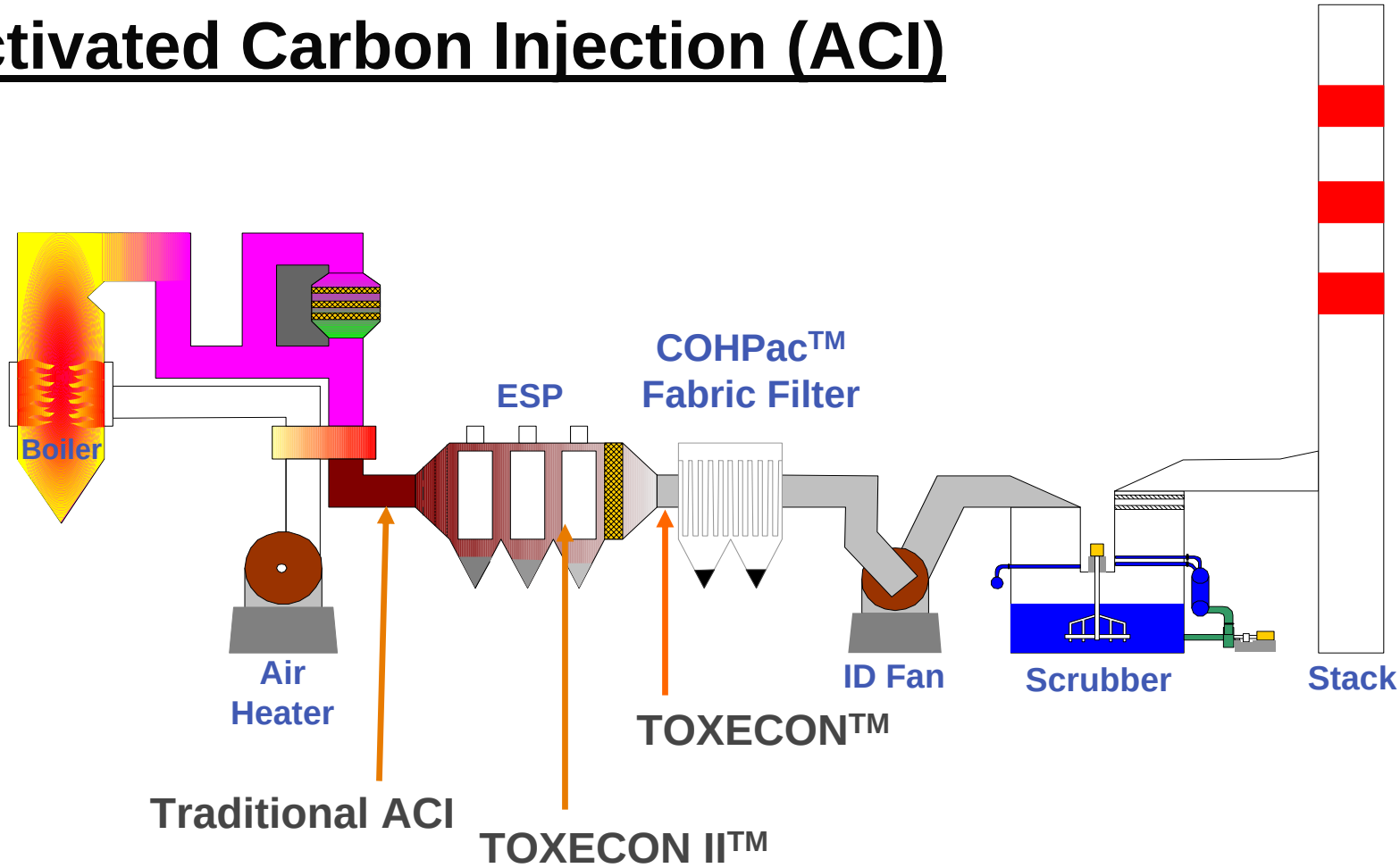
Background

Activated Carbon Injection (ACI)

- **Most mature Hg control technology – utility applications**
- **Attractive technology**
  - **Low capital costs**
  - **High levels of Hg removal demonstrated**
  - **Operational flexibility**
    - **Control reagent usage to attain desired performance**
    - **Different operational configurations available**

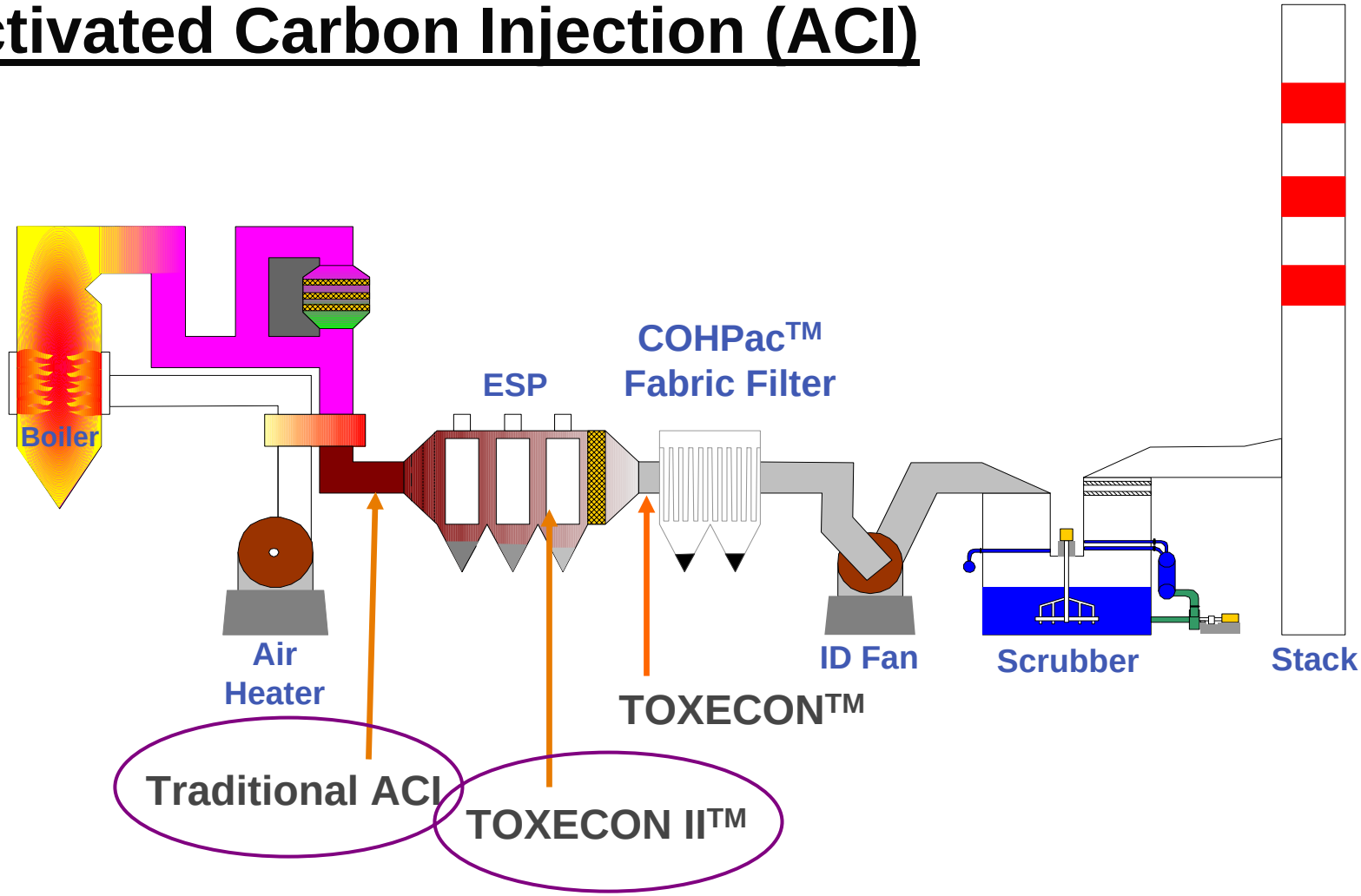
Background

Activated Carbon Injection (ACI)



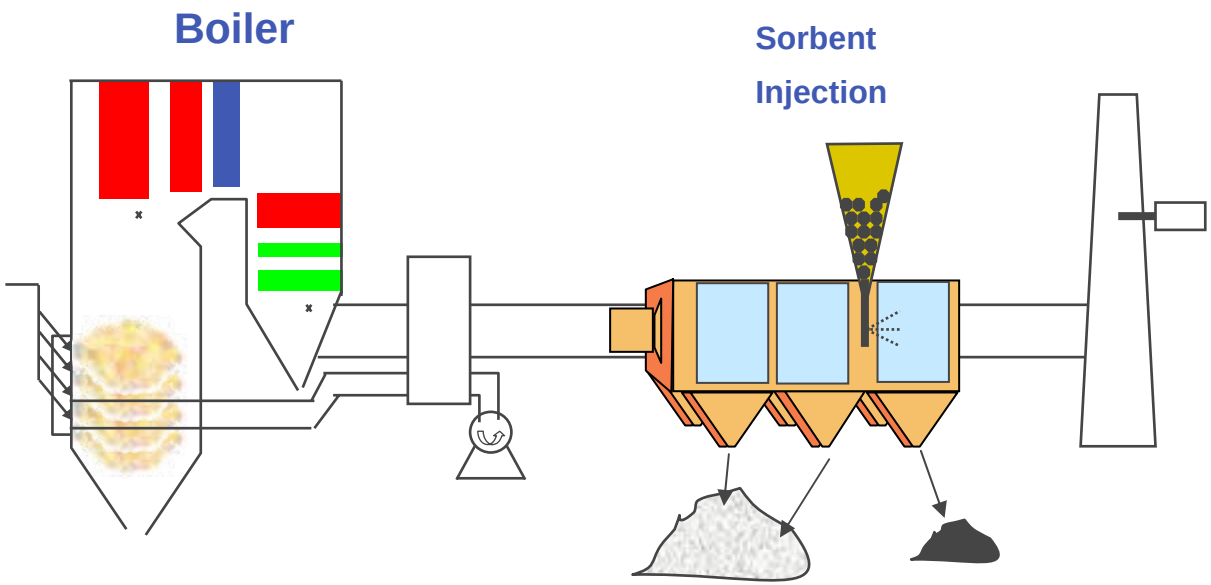
Background

Activated Carbon Injection (ACI)



Background

Toxecon™ II



Background

Activated Carbon Injection (ACI)

- **Performance & cost impacted by many parameters**
  - **Fuel type**
  - **Plant configuration**
  - **Plant operating parameters**
- **Balance of plant effects**
  - **Fly ash properties (may impact reuse)**
  - **Particulate control device operation**
    - **Baghouse pressure drop**
    - **ESP performance**

URS

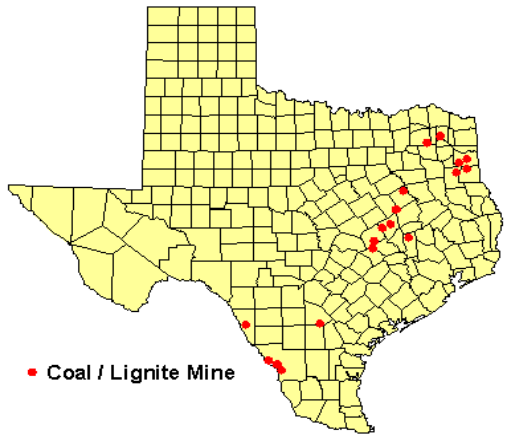
Background

Mercury Sorbents

- **Activated Carbon (AC)**
  - **Coal, lignite precursor materials ($0.35 - $0.60/lb)**
  - **Chemically-treated AC**
    - **Halogen-impregnated ($0.85 - >$7.00/lb)**
- **Non-carbon sorbents**
  - **Zeolite, silicate, treated clay, etc.**
  - **Limited performance data**
- **Development areas**
  - **Low impact on fly ash**
  - **High temperature applications**
  - **High SO_3 applications**

Background – Texas Lignite

- **TxL accounts for ~5% of U.S. coal fired**
  - **~10% of U.S. utility Hg emissions**
- **Challenges for Hg control**
  - **Fuel properties can be quite variable**
    - **Fluctuating flue gas Hg levels**
    - **TxL/PRB blends**
  - **Relatively low fuel chlorine levels**
    - **Flue gas Hg oxidation typically 25 – 50%**
  - **Low heating value**
    - **High gas volumes**
    - **Relatively high flue gas temperatures**



Background – Texas Lignite

- **ACI in TxL flue gas**
  - **Most tests performed at small-scale**
  - **Limited or no full-scale ESP tests performed**
- **Sorbent impact on fly ash is a concern**
- **Needed information:**
  - **What sorbents are effective in TxL-derived flue gas?**
  - **Can ACI be effective while preserving fly ash resale?**

Project Organization

Project Team

- **NETL** [primary funder; COR-Sara Pletcher]
- **EPRI** [co-funder; technical guidance]
- **NRG Texas** [host site provider; co-funder]
- **AEP** [co-funder; technical consultant]
- **TXU Energy** [co-funder; technical consultant]
- **Apogee Scientific** [design, testing support]
- **ADA-Environmental Solutions LLC** [design, consultant support]
- **URS Corporation** [prime contractor]

URS

Project Team – Key Personnel

- **NETL – Sara Pletcher (COR)**
- **EPRI – Ramsay Chang (Project Manager)**
- **NRG Texas – Craig Eckberg (Project Liaison)**
  - John Hudspeth (LEGS Plant Lead)
- **AEP – Gary Spitznogle (Project Liaison)**
- **TXU Energy – Bob Wiemuth (Project Liaison)**

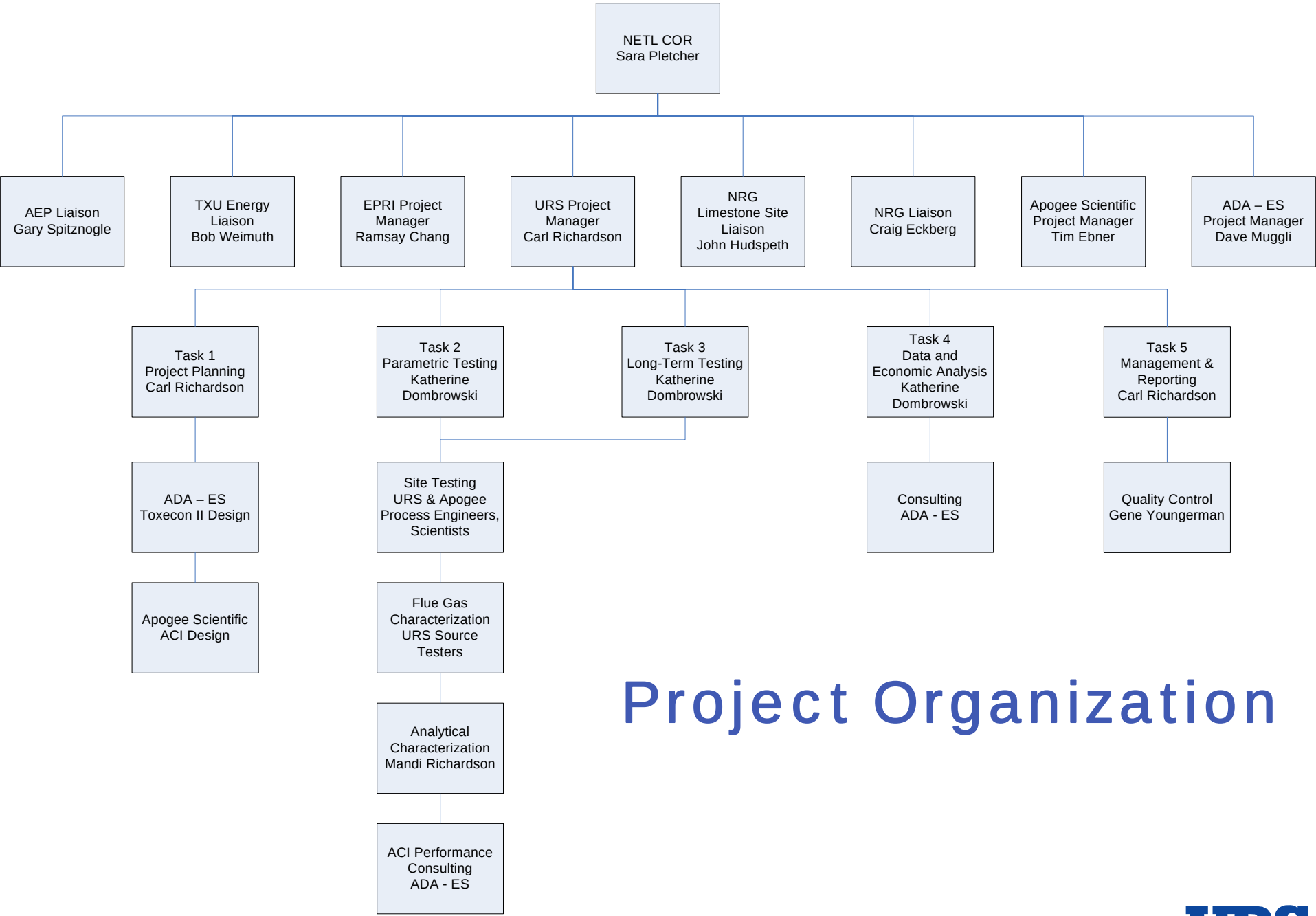
URS

Project Team – Key Personnel

- **URS** – Carl Richardson **(Project Manager)**
  - Katherine Dombrowski **(Asst. PjM)**
  - Mandi Richardson **(Analytical Lead)**
  - Gene Youngerman **(QC Manager)**
- **Apogee** – Tim Ebner **(Project Manager)**
- **ADA-ES** – Dave Muggli **(Project Manager)**

Project Organization

- **Task 1**: Project Planning/Equipment Design
- **Task 2**: Parametric Testing
- **Task 3**: Long-term Testing
- **Task 4**: Alternate Fuel Blend Test
- **Task 5**: Data and Economic Analysis
- **Task 6**: Management & Reporting



Project Organization

Technical Approach

Host Site – NRG Texas Limestone Electric Generating Station (LEGS): Jewett, TX

- **Unit 1 or 2**
  - **Unit 1: 890 MW**
  - **Unit 2: 930 MW**
    - **DOE Pegasus program**
  - **Split tangential boilers**
- **Fuel**
  - **Blend of Texas lignite and PRB coal**
    - **Typically fire 70/30 blend**

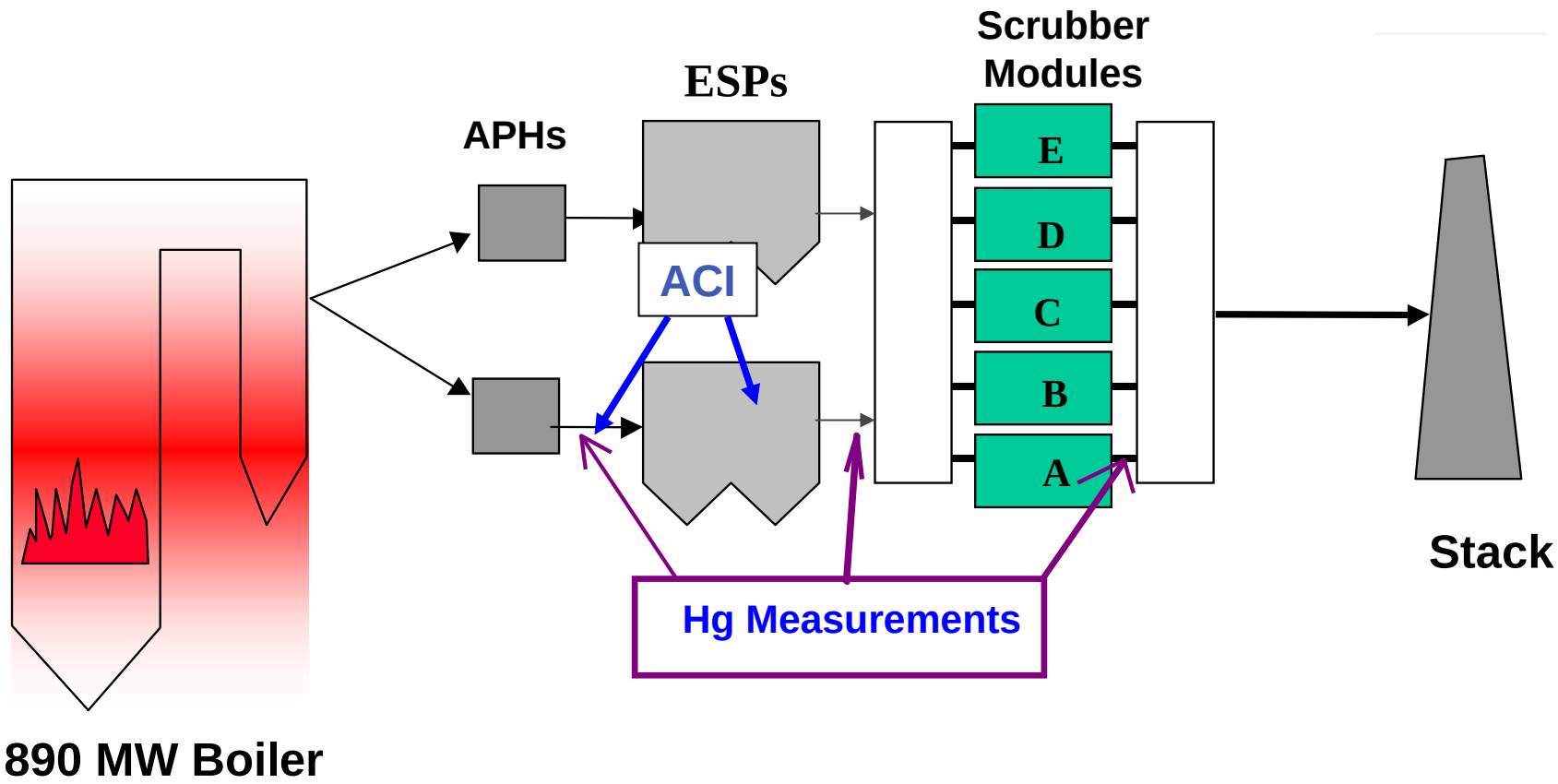
Fuel Type	Texas Lignite	PRB
Heating Value (as received)	5500-6900 Btu/lb	7900-8300 Btu/lb
Ash	15-27%	4-8%
Sulfur	0.9-1%	0.3-0.5%
Water	29-32 %	30%
Mercury	0.15-0.22 ppm	0.06-0.10 ppm
Chlorine	50-100 ppm	25-60 ppm

Limestone Unit 1 Mercury

- **Mercury levels – ESP inlet location**
  - **20–35 µg/Nm³ @ 3% O_2**
  - **25–45% Hg oxidation**
    - **~3 ppm HCl in flue gas**
- **Low Hg removal across ESP**
  - **<5% removal**
  - **Low ash UBC levels**
  - **Fly ash sold for reuse**

URS

Limestone Unit 1 or 2 Configuration



Limestone Sorbent Injection
Proposed Tests

Short-term parametric tests - 2 phases (Task 2)

1. **Sorbent Injection Upstream of ESP**
   - Effect of sorbent type (3 sorbents)
   - Effect of sorbent injection rate
   - Evaluate Hg removal performance; impacts on fly ash
2. **Toxecon™ II Evaluation**
   - Effect of sorbent type (2 sorbents)
   - Evaluation of staged sorbent injection
   - Comparison of process configurations
     - Traditional ACI
     - Toxecon™ II
     - Staged injection

URS

Limestone Sorbent Injection
Proposed Tests

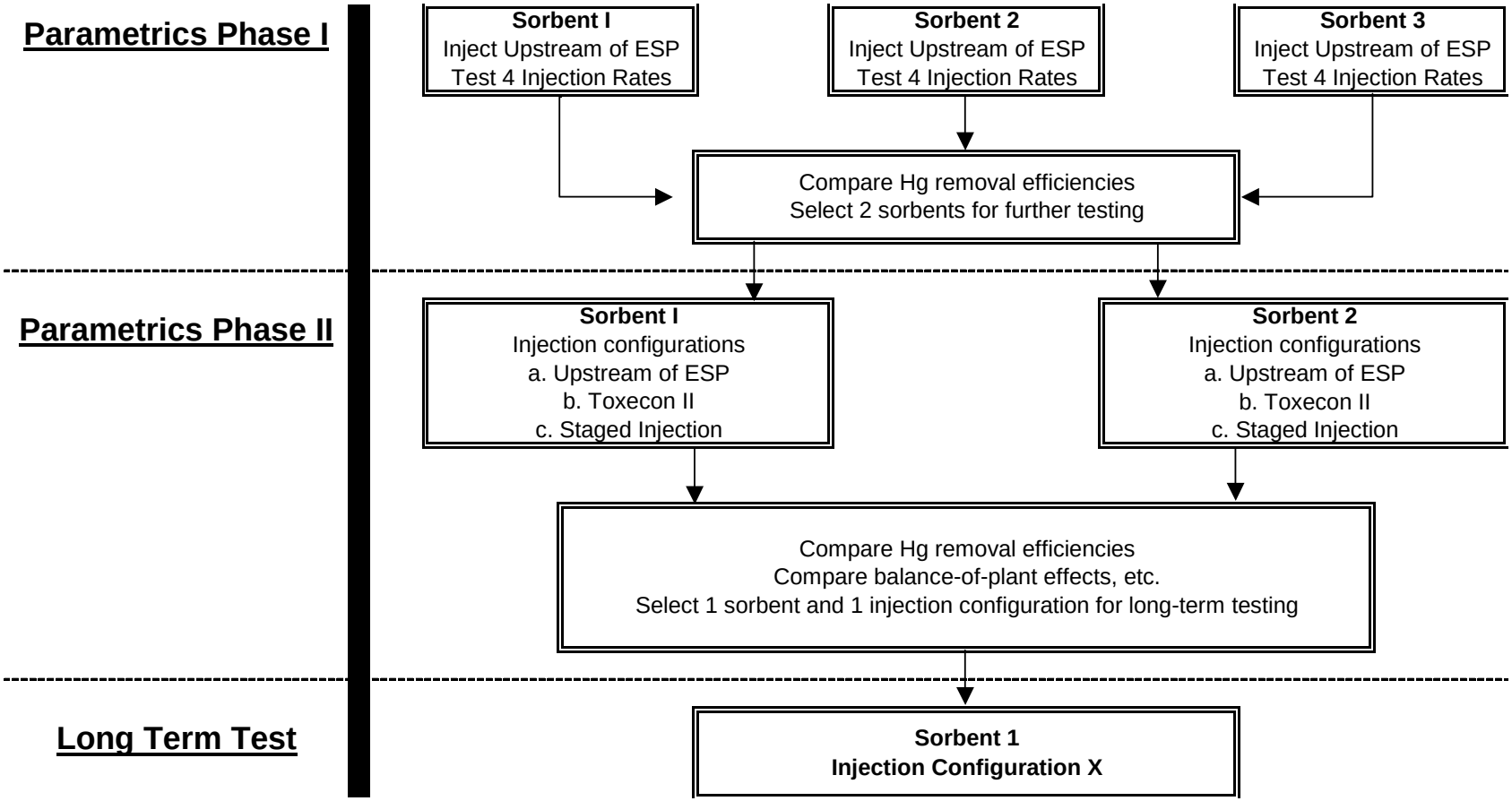
Long-term Sorbent Injection Test (Task 3)

- Test conditions determined from parametric results (performance vs. cost analysis)
  - **Process configuration**
  - **Sorbent**
  - **Injection rate**
- Continuous injection test
  - **60-day test**
  - **Evaluate process performance & variability**
  - **Balance of plant impacts**

Limestone Sorbent Injection
Proposed Tests

- **Alternate fuel-blend test (Task 4)**
  - **Extension of continuous injection test**
  - **Vary TxL/PRB fuel blend**
  - **7-day test**
  - **Extended baseline period following test to characterize emissions at alternate fuel blend with no sorbent injection**

Limestone Sorbent Injection Testing Logic



Limestone Sorbent Injection
Sorbents

Sorbents to be selected based on available performance & cost information

- **Low-cost activated carbon**
  - **e.g., Darco-Hg**
- **Halogen treated activated carbon**
  - **e.g., bromine-impregnated AC**
- **Low fly ash impact sorbent**
  - **Non-carbon sorbent**
  - **AC with low impact on ash properties**

URS

Proposed Parametric-1 Test Matrix

Test No.	Sorbent	Injection Rate (lb/Mmacf)	Proposed Schedule
BL1	None	0	Days 1-2
AC11	Low-Cost AC	3	Day 3*
AC12	Low-Cost AC	5	Day 3*
AC13	Low-Cost AC	7	Day 4*
AC14	Low-Cost AC	9	Day 4*
BL2	None	0	Day 5
AC21	Br-AC	1	Day 6*
AC22	Br-AC	2	Day 6*
AC23	Br-AC	3	Day 7*
AC24	Br-AC	5	Day 7*
BL3	None	0	Day 8
AC31	Low Ash Impact	3	Day 9*
AC32	Low Ash Impact	5	Day 9*
AC33	Low Ash Impact	7	Day 10*
AC34	Low Ash Impact	9	Day 10*
BL4	None	TBD	Day 11

* - 4 hour tests

URS

Proposed Parametric-2 Test Matrix

Test No.	Config.	Injection Rate (lb/Mmacf)	Proposed Schedule
BL5	None	0	Days 1-2
T1-11	ESP Inj	TBD	Day 3
T1-21, 22	Toxecon II	3, 5	Day 4*
T1-23, 24	Toxecon II	7, 9	Day 5*
T1-31, 32	Dual-Inj	TBD (2 rates)	Day 6*
T1-33, 34	Dual-Inj	TBD (2 rates)	Day 7*
BL6	None	0	Day 8
T2-11	ESP Inj	TBD	Day 9
T2-21, 22	Toxecon II	1, 2	Day 10*
T2-23, 24	Toxecon II	3, 5	Day 11*
T2-31, 32	Dual-Inj	TBD (2 rates)	Day 12*
T2-33, 34	Dual-Inj	TBD (2 rates)	Day 13*
AC32	None	0	Day 14

* - 4 hour tests

Proposed Longer-Term Injection Test

- **60-day continuous injection test**
  - **Test configuration and sorbent determined from parametric test results**
  - **Injection rate will follow unit load**
- **Flue gas characterization testing**
  - **Continuous performance feedback via SCEMs**
  - **Ontario Hydro testing (three sampling events)**
  - **Sorbent tube/Appendix K verification**
  - **PM measurements to verify ESP performance**
- **Byproduct characterization (if applicable)**
  - **Fly ash concrete use evaluation tests**

URS

Proposed Longer-Term Injection Test

- **Optional 1-wk test at an alternate fuel blend**
  - **Extend continuous injection test by 7 days to evaluate an alternate TxL/PRB blend**
  - **Test will depend on ability of plant to modify blend at time of test**
  - **Extended ‘baseline’ measurement period at end of test to characterize emissions**

Sorbent Injection Test Equipment
EPRI Sorbent Feeder

Dry sorbent feeder

- **Low pressure pneumatic conveying**
- **15 to 500 lb/hr**
- **900 lb sack capacity**
- **Direct feed from tanker**

Sorbent Injection Equipment
Injection Lances

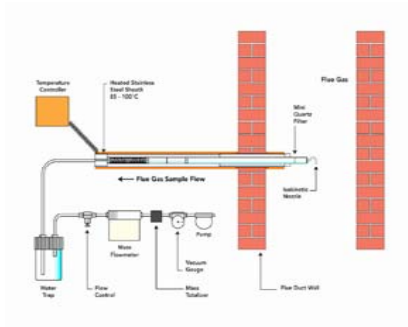
- **ESP Injection tests**
  - **Injection lances installed upstream of ESP**
  - **Treat entire duct (ESP)**
  - **Apogee will design injection system**
- **Toxecon™ II Injection Grid**
  - **Grid installed in ESP**
  - **Treat one-half of ESP**
  - **ADA-ES will design system**

Experimental Measurements

Flue Gas Hg concentrations

- EPRI semi-continuous mercury emission monitors
  - **ESP inlet, ESP outlet, FGD outlet**
  - **24/7 measurements**
  - **Speciated Hg**

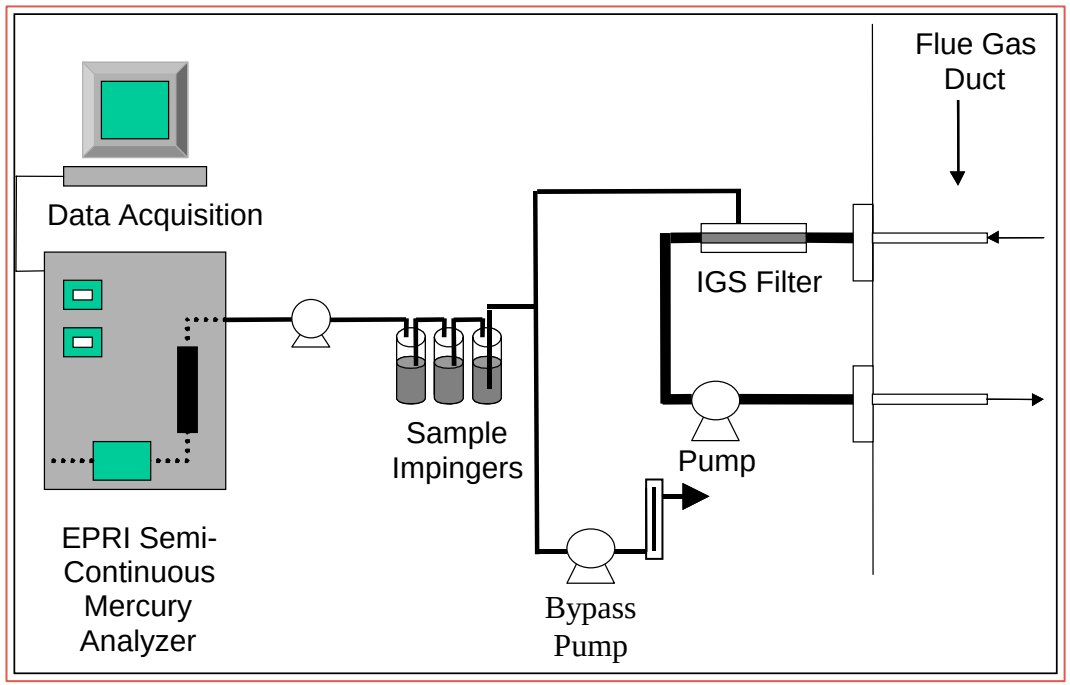
- Carbon tube measurements
  - **Verification of SCEM data (each location)**
  - **Measurement of probe sample stream**
  - **Appendix K**



- Ontario Hydro
  - **Measurements across ESP**
  - **Triplicate runs -baseline and (3) long-term injection tests**

URS

Schematic of Hg SCEM



Flue Gas Characterization

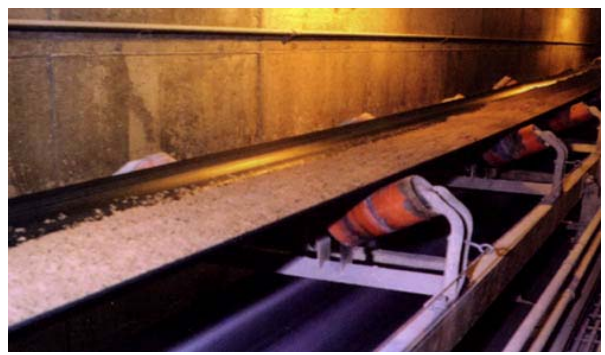
- **Flue Gas Velocity**
  - **Method 1**
- **Halogen Levels**
  - **M26a for Cl, Br, F (ESP inlet)**
- **Particulate Loading**
  - **M17 or M5 (ESP inlet, outlet)**
  - **Continuous particulate analyzer (BHA CPM 5001)**
- **SO_3 measurements?**
  - **CCS method would be used**

URS

Limestone Sorbent Testing
Process Samples

- **Coal**
  - **Hg, Cl, F, Ult/prox., HHV**

- **ESP fly ash**
  - **Hg, LOI content**
  - **Mercury stability tests (NETL samples)**
  - **Concrete reuse evaluation tests**
- **FGD gypsum slurry**
  - **Hg, inerts (liq. vs solid)**

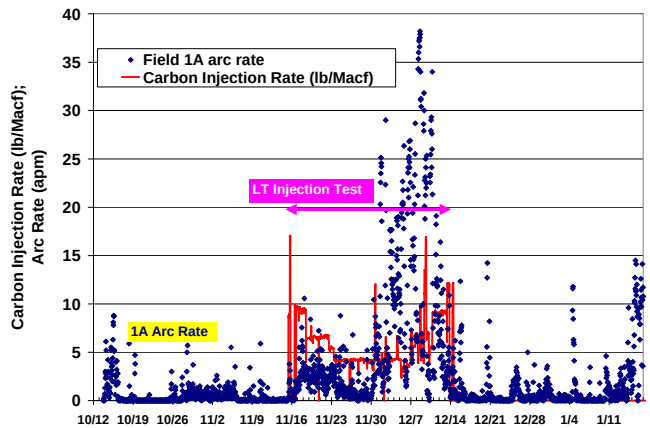


- **FGD makeup streams**
  - **Hg**

URS

Limestone Sorbent Testing
Process Data

- **Boiler**
  - **Unit load, coal flow**
- **Available duct temperatures**
- **CEM data**
  - **NO_x, O_2, CO_2, SO_2**
- **Opacity**
- **ESP VI curves**



Analytical Characterization

- **URS Mercury Analytical Lab (Austin, TX)**
  - **Flue gas characterization samples**
    - **OH, sorbent tube samples**
    - **M26a, M17 samples**
  - **Process samples**
    - **Coal, fly ash, scrubber Hg determinations**
    - **Coal halogens**
    - **Fly ash LOI**
    - **Fly ash foam index**

- **SGS (Denver, CO)**
  - **Coal Ult/prox analysis**
- **Fly ash evaluation for concrete reuse**
  - **Boral or Headwaters**

URS

Data and Economic Analysis (Task 5)

- **Analysis of testing data**
  - **Validation, reduction, analysis of data**
  - **Quality control analysis**
  - **Mercury material balance calculations**
  - **Balance of plant impact determination**
- **Evaluation of process costs**
  - **Estimate capital and operating costs of selected configuration**
  - **Installation requirements**
  - **Performance vs. cost**
  - **Balance of plant considerations**

URS

Project Schedule

Project Schedule

	Q406			Q107			Q207			Q307			Q407			Q108			Q208			Q308			
Months After Contract Award	Jl	A	S	O	N	D	J	F	M	A	Ma	Jn	Jl	A	S	O	N	D	J	F	M	A	Ma	Jn	Jl
Task 1: Project Planning																									
1.1 Test Plan																									
1.2 QA/QC Plan																									
1.2 Kickoff Meeting																									
1.3 Sorbent Injection Equipment Design/Build																									
Task 2: Parametric Testing																									
2.1 Hg SCEM Measurements																									
2.2 Continuous Particulate Measurements																									
2.3 Manual Gas Sampling																									
2.4 Laboratory Analysis																									
2.5 Concrete Evaluation of Ash																									
Task 3: Long-term Testing																									
3.1 Hg SCEM Measurements																									
3.2 Continuous Particulate Measurements																									
3.3 Manual Gas Sampling																									
3.4 Laboratory Analysis																									
3.5 Concrete Evaluation of Ash																									
Task 4: PRB/TxL Blend Testing																									
Task 5: Data and Economic Analysis																									
Task 6: Management and Reporting																									
6.1 Program Management																									
6.2 DOE/NETL Review Meetings																									
6.3 Technical Conference Presentations																									
6.4 Reporting			Q			Q			Q			Q			Q			Q			Q			Q,F	F

(Q = Quarterly report, F = Final report)

URS

Project Schedule

Possible Impacts on Schedule:

- **Toxecon II installation**
  - **Design/external fabrication schedule**
  - **Plant outage schedule**
    - **7-day outages planned on both units in Feb-07**
- **Equipment/personnel scheduling**

URS

Project Milestones and Deliverables

Project Milestones

Milestone	Description	Planned Completion
1	Site Survey	Q206
2	Project Kickoff Meeting	Q306
3	Draft Test Plan Completion	Q306
4	Equipment Design	Q406
5	QA/QC Plan Development	Q406
6	Finish Parametric Testing - 1st Phase	Q107
7	Sorbent Selection 2nd Phase	Q107
8	Sorbent Selection for Extended Testing	Q207
9	Finish Parametric Testing - 2nd Phase	Q207
10	Extended Testing	Q307
11	Inititate Concrete Analysis	Q407
12	Complete Laboratory Analysis	Q108
13	Complete Data Analysis	Q208
14	Economic Analysis	Q208
15	Complete Draft Final Report	Q208

Project Deliverables

- **Project test plan**
- **Hazardous Substance Plan**
- **QA//QC Plan**
- **Health & Safety Plan**
- **Hazardous Waste Report**
- **Project Status Reports**
- **Site Report**
- **Final Report**
- **Report of Termination/Completion Inventory**

Questions?

Limestone TOXECON II Grid Design

U.S. Department of Energy
NETL
Project Kickoff Meeting
August 2, 2006

Dave Muggli
ADA-ES, Inc.

DOE Cooperative Agreement
DOE/NETL Project Manager: Sara Pletcher

Injection Grid Design Factors…

ADA-ES

Grid Design Factors

- ESP geometry and physical configuration
- ESP SCA
- ESP existing performance
- Hopper ash collection quantity profile
- Flue gas flow rate
- Flue gas profile within ESP

Grid Design Factors

- Removable vs fixed grid
- Ability to make minor changes to ESP internals, particularly plate suspension
- Pressure and air and PAC flow capability of injection skid
- Outage duration for installation

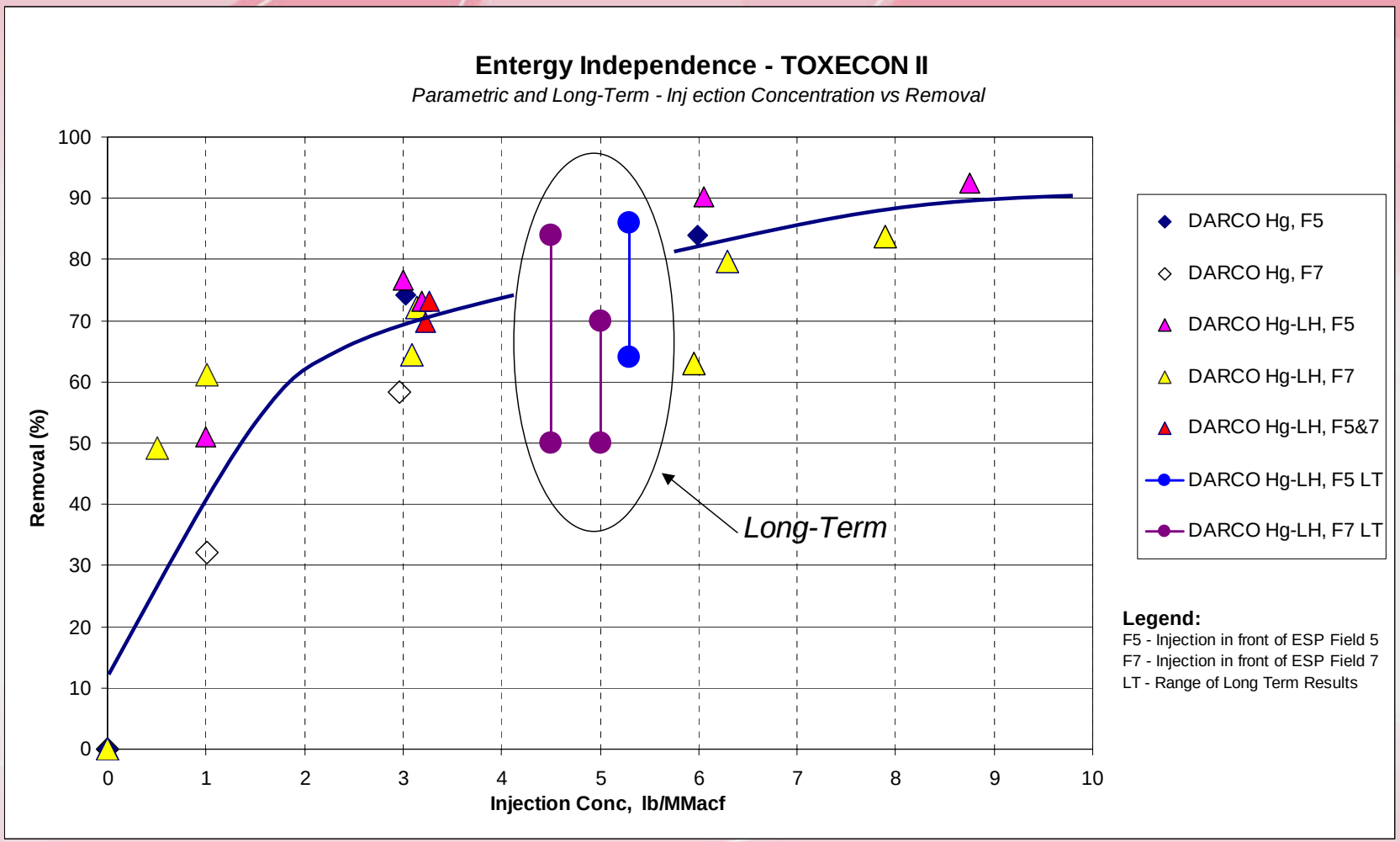
Status of Independence Grid Design…

ADA-ES

Independence Grid Design

- **Problems:**
  - Believe the current design doesn't give good distribution
  - Lower than expected Hg removal rates
  - Can't explain high removal rates during parametric, falloff during long term
  - Can't explain high removal rates at low load, falloff at high load
  - Plugging with low grid flow rates

Independence Grid Design



Independence Grid Design

- **Efforts in Progress:**
  - Physical and CFD ESP and grid modeling
  - Evaluating distribution, spray patterns
  - Evaluating ESP flow profile
  - Working on grid PAC distribution redesign
  - Working on externally removable grid design

Independence Grid Design

1.0 acfm
-
(normal~
1.0 acfm)

0.305 in hole

Brass Nozzle

ADA-ES

Independence Grid Design

0.74 acfm -

(normal ~ 1.0 acfm)

ADA-ES

Independence Grid Design

2.7 acfm -

(normal ~ 1.0 acfm)

ADA-ES

Independence Grid Design

3.7 acfm -

(normal ~ 1.0 acfm)

ADA-ES

Independence Grid Design

- **Future Activities:**
  - Expect modeling results within next two months
  - Expect to install and test revised grid at Independence
  - Anticipate results late 2006 or early 2007

Design Challenges for Limestone…

ADA-ES

Limestone Design Challenges

- Maintaining electrical clearance around DE bracing frame
- Penetrating through ESP roof
- Grid routing inside ESP Box

Limestone Design Challenges

DE Frame

ADA-ES

Limestone Design Challenges

ESP Roof

ADA-ES

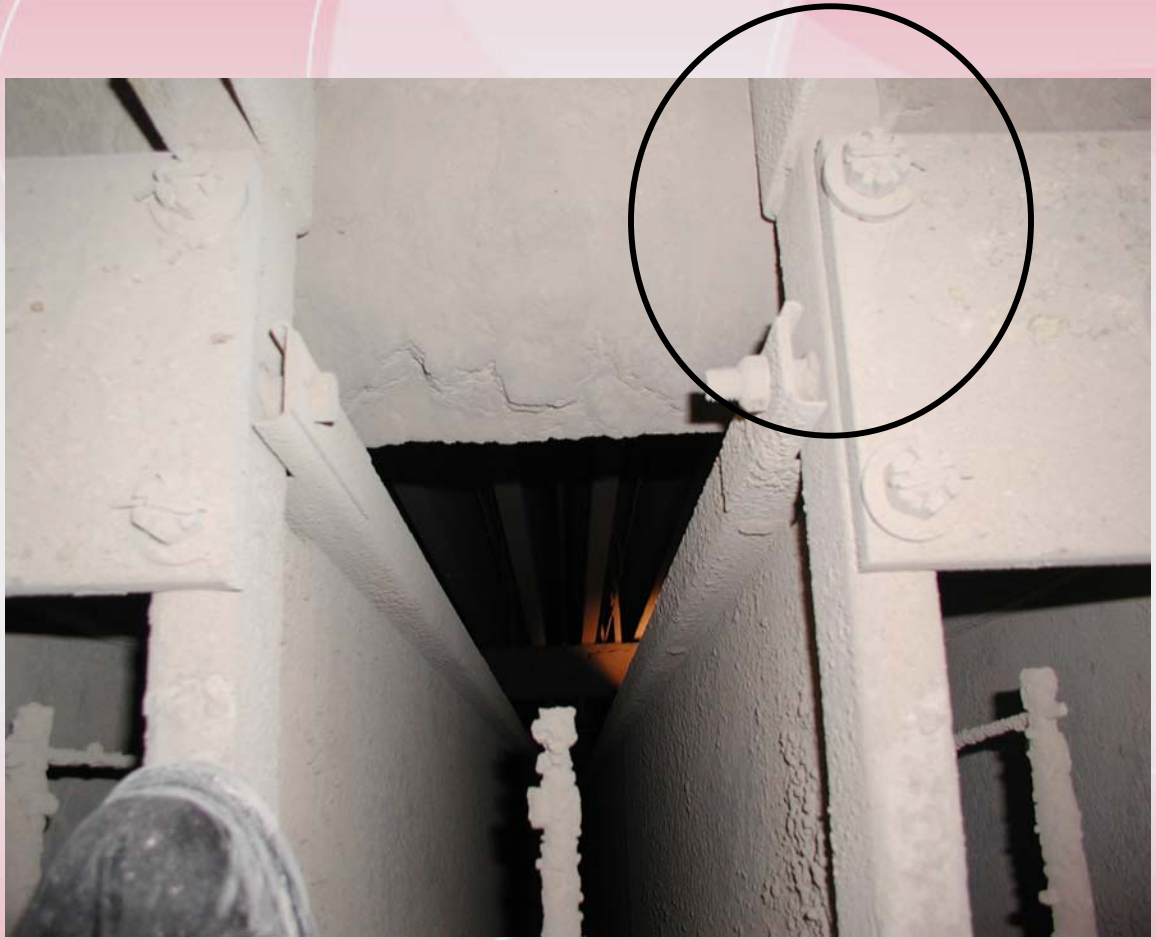
Limestone Design Challenges

Inside ESP Box

ADA-ES

Limestone Design Challenges

Inside ESP Box



ADA-ES

Limestone Information Needs…

ADA-ES

Limestone Needs

- ESP flow modeling or results from previous flow modeling studies if available
- Hopper ash collection data
- Injection skid flow and pressure capabilities
- More detailed drawings for ESP roof and internals
- Plant visit during outage to take actual measurements and additional photos

Limestone TOXECON II Grid Design

U.S. Department of Energy
NETL
Project Kickoff Meeting
August 2, 2006

Dave Muggli
ADA-ES, Inc.

DOE Cooperative Agreement
DOE/NETL Project Manager: Sarah ????